UDC 666.3.032.62:621.365.3

ELECTRIC HEATING OF CERAMIC MIXTURE IN MOLDING

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Translated from Steklo i Keramika, No. 8, pp. 16 – 17, August, 2003.

A structural scheme of a set for electrode heating of plastic ceramic mixtures in extrusion molding is considered. The preferred areas of application of this heating method in the production of technical and household products are specified.

Processing a raw material into an intermediate and then into a finished piece involves a modification of its composition, structure, and properties. Fine ceramic technology based on the principles of physicochemical mechanics [1] calls for the development of new high-speed regimes of mechanical and thermal treatment of materials and intermediate products.

It is known from the practice of thermal treatment of molded ceramic articles that crack usually originate in the initial stage of drying [2]. Later cracks do not emerge, as a rule, although the difference in the moisture content across the thickness of a product remains the same or even slightly increases at a certain stage of drying, whereas the average moisture decreases. It is known that a decrease in the molding moisture makes it possible to substantially increase the intensity of drying.

In molding flat porcelain articles, such as plates, surface heating of a molded piece with electric current is commonly used [3], which provides for high quality of the surface of the piece treated and prevents its adhesion to the molding roll. However, moisture in this case is unevenly distributed across the thickness of the article, which results in nonuniform shrinkage of different layers of the article. The most heated outer layers tend to decrease in size, whereas the inner layers that retain their original size impede the shrinkage of the surface layers. At the same time the surface layers rapidly shrink, as a consequence of which tensile stresses arise on the surface of the article and compressive stresses arise inside, which may cause dangerous deformation, warping, and emergence of cracks.

Researchers at the Institute of Ceramic Machine Building have carried out research based on electric heating of porcelain mixture in molding by passing an electric current through the article. Such electric heating has not been previously used (electric-spark sintering is based on other principles). Indirect electric heating is used, for instance, in hot molding of silicon nitride, some high-melting compounds, etc. The relative simplicity of the method, its obvious efficiency, and the technological opportunities ensuing from have motivated our research and development activities.

The Institute has developed a set for continuous production of molded electroceramic rods (USSR Inventor’s Certif. No. 1595648) and tested it in laboratory conditions. The structural scheme of this set is shown in Fig. 1.

The set includes a mechanism for compulsory pushing of plastic ceramic mixture, which represents a screw conveyor *1* placed in a case *2* and connected with the rotational drive *3*. The set also includes a circular *4* and a rod *5* conducting electrodes, electrode *5* being joined with cross-bars *6* and a sealing ring *7*. Electrodes *4* and *5* are insulated from each other by an insulating pad *8* and fixed at the output flange of the case, the circular electrode *4* being located coaxially to the screw conveyor and the rod electrode *5* being positioned coaxially inside the cavity of electrode *4*.

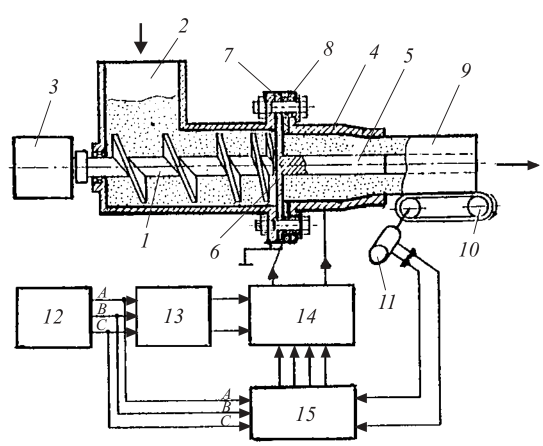

Fig. 1. Structural scheme of a set for continuous production of tubular molded pieces.

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0361-7610/03/0708-0246$25.00

A long ceramic bar *9* is arranged on a delivery belt conveyor *10*, which has a velocity transducer *11* (for instance, tachogenerator) installed on the shaft of one of the drums.

Furthermore, the set contains a three-phase power source *12* connected to the inlets of the rectifier *13*, a current converter *14* (converting direct to alternating current), and a synchronizer *15*.

Technical Specifications of the Set

Output, kg/h	200
Drive wattage, kW	5
Mixture heating temperature, °C	60
Voltage, V	380
Overall sizes, mm	
length	1100
width	725
height	1000
Weight, kg	930

The set functions as follows. As screw conveyor *1* is rotated by the drive *3*, a plastic ceramic mixture is compulsorily extruded via the cylindrical part of the case *2* and passes between the cross-bars *6* and then between electrodes *4* and *5*. Alternating current from converter *14* supplied to electrodes *4* and *5* (arriving at electrode *5*, accordingly, via ring *7* and cross-bars *6*) is closed via the ceramic mixture in the space between the specified electrodes and heats the mixture. A heated intermediate bar *9* arrives at conveyor *10* and, under the effect of gravity, is pressed to the belt and, sticking to the belt, sets the conveyor in motion, whereas the rotational speed of its drums varies synchronously with the variations in the speed of extruding the bar. The velocity transducer *11* connected to one of the drums produces voltage, whose value is proportional to the bar extruding velocity.

It should be noted that three-phase alternating voltage of power source *12* is rectified by rectifier *13* and fed to the power input of converter *14*, converting direct current into alternating current. The latter is also a regulator of the strength of current passing through the ceramic mixture within the space between electrode *4* and electrode *5*, which is insulated from electrode *4* by the insulating pad *8* and, accordingly, operates as a regulator of the degree of heating of ceramic mixture.

Signals controlling and monitoring the current passing through the ceramic mixture are generated by synchronizer *15*, which has four outputs connected to the corresponding (control) inputs of converter *14*.

The amount of heat emitted inside the ceramic mixture is proportional to the time that the converter elements stay switched on. As the extrusion velocity increases, the time it stays between electrodes *4* and *5* decreases; consequently, it becomes heated. However, at the same time the voltage of the velocity transducer grows; consequently, the time the converter elements stay switched on increases, which facilities a proportional increase of heat released in the ceramic mixture per time unit. On the other hand, as the extrusion velocity decreases, the quantity of heat released in the mixture extruded per time unit decreases. As a result, different parts and layers of the intermediate piece are equally heated, regardless of the extrusion velocity.

Providing uniform and equal heating of an intermediate article at different extrusion velocities makes it possible to avoid overheating of certain areas, to stabilize the duration of subsequent drying of intermediate products, and, accordingly, to avoid the emergence of cracks and improve the quality of intermediate and finished articles.

Research carried out at the Institute revealed the following.

Efficient electric heating of a ceramic mixture can be achieved only by including it in an electric circuit as active resistance, i.e., by electrode heating. Any other method of heat supply, for instance, outer contact supply, does not ensure the required volumetric homogeneity of heating. The high efficiency achieved here is presumably due not to some specific effect of electric current, although such effect may exist, but due to the temperature-time factor and increased compaction of the initial components of ceramic mixture in a hot state.

Electrode heating of ceramic mixtures is recommended for extruders, i.e., machines for extruding ceramic mixtures via profiled openings, and can be also used in the production of electromechanical, construction, household, and other elongated ceramic products such as pipes, belts, rods, etc.

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